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# A first experience of flipped classroom in numerical analysis

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**Abstract**

Flipped classroom is a pedagogical model that modifies the way that time is spent both in and outside the class, working with active learning, centered on the students. Do students accept flipping the classroom? What do they think about learning with recorded classes? These questions arise when the flipped model is to be implemented. A first experience of flipped classroom was carried out in a numerical analysis course at Facultad Regional San Nicolás, and students' opinions about this experience were gathered, so as to determine the acceptability of this methodology. The experience showed a high degree of acceptance by the students with respect to the methodology of the flipped class. Students were satisfied with the videos presented, and in general they preferred to work on their own in class, with the assistance of the faculty.


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*Keywords:* flipped classroom; learning styles; numerical analysis

## 1. Introduction

Flipped classroom is a pedagogical model that modifies the way that time is spent both in and outside the class, working with active learning, centered on students.

Questions like "Do students accept flipping the classroom?", "What do they think about learning with recorded classes?" arise when we think about changing the way of teaching from the classical model of expositive classes to

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the flipped methodology. With the purpose of determining the acceptability of the methodology of flipped classroom, a first experience was implemented in a numerical analysis course, belonging to the career Industrial Engineering, at Facultad Regional San Nicolás, Universidad Tecnológica Nacional from Argentina. The issue "Interpolating polynomials and spline functions" was selected.

To carry out the experience, videos were created with appropriate tools, and a didactical sequence was given to the students in a virtual platform. This sequence included links to the videos –some containing theory and others, solved exercises–, the order that must be followed to watch them, and some questions about the subject being studied, together with some suggested exercises to be done, following the ones given in the videos. Then, during the class, definitions and properties were reviewed and active participation of students was reached when exercises were solved. After that, a survey was conducted so as to gather the students' opinions.

The experience showed a high degree of acceptance by students with respect to the methodology of the flipped class. Students were satisfied with the videos presented, and in general they preferred to work on their own in class, with the assistance of the faculty.

The methodology of the flipped class fitted the predominant learning styles of the group of students.

With the videos produced for this experience, together with the material offered on the websites of the subject, students have the necessary tools to achieve autonomy in the study of theory, making it possible to change the way of working in class.

## 2. Theoretical approaches

Students' engagement is one of the essential factors for effective teaching, and this engagement is critical for learning (Barkley, 2010; Coates, 2006). Regarding this, Bryson & Hand (2007) state that students would be more likely to get involved if teachers proposed activities that "invite them", if they asked for results and challenges for a higher order of thinking. Hockings, Coole, Yamashita, McGinti & Bowl (2008) suggest that most engaged students guess, ask, assess, connect ideas, as opposed to those not involved, taking only superficial contact with learning taking notes, focusing on punctual things without analysis, going directly to conclusions (O'Flaherty & Phillips, 2015). In the last years a new pedagogical model arose, supported by new technologies, which engages students with their learning: the flipped classroom. According to Touron, Santiago et al. (2013), the flipped classroom is a didactic model in which students learn new contents by video-tutorials on line, generally at home; and what was used to be homework, is now carried out in the classroom, with personalized orientation and interaction with students. In other words, the flipped class consists in taking out the traditional theoretical class, so as to use the class time with active learning, that is to say, including activities with participation of students: simulations, discussions, experiences, among other examples. Thereby, students get engaged with activities of participative learning.

Although the latest technology seems to be essential in flipped classrooms, the pedagogy behind this perspective is not new. For a long time, teachers have required students to come to class having read certain texts. The flipped learning model simply uses new technologies so as to give audiovisual options to students for preparing classes. The most important thing of this perspective is the definition of the class-time as a student-centered environment (Sams & Bergman, 2013). From the point of view of See & Conry (2014), the model of a flipped classroom can be thought of as a proposal that suggests moving the contents located on the lower levels of the revised Bloom´s Taxonomy (Krathwohl, 2002) –understanding and memorizing– out of the class, and saving the class time for the upper levels – creation, evaluation, analysis and application– without necessarily using techniques that require technology such as videos on YouTube, or class recording, among others.

Some of the advantages of the flipped class, by experts´ agreement (Walsh, 2013) are:

- The flipped class produces greater student engagement: explaining the lesson in a traditional classroom is a passive activity for students, but when lessons are uploaded to an online system, time of class can be used for solving problems, collaboration activities and group discussions, thus increasing students' engagement with learning.
- The flipped class produces deeper learning: this model allows spending more time in class on the higher categories of Bloom´s Taxonomy – analysis, evaluation and creation – rather than on the lower ones – memorizing and understanding-, which are done outside the classroom.

- The flipped class lets students learn at their own pace: in traditional classes an average pace is reached, therefore some students get bored while some others cannot keep up with that pace. In contrast, on the flipped class students take more control over the content of the explanations and they can manage their own pace (by pausing the video-tutorial so as to take notes, or rewind whenever it is necessary). Meanwhile, time in class is gained as a superior order of thinking is being promoted. Besides collaboration and participation of students is increased, as faster students can help the slower ones with their assignments.

Although this model is relatively new, over the past two years a number of articles and research projects on the topic have been written. They share class experiences but no conclusive results regarding the implementation of this methodology.

## 3. The experience

### *3.1. Learning styles of the students*

Felder and Silverman classified the students' learning styles according to four dimensions which at the same time are composed of two categories. Each dimension refers to the ways in which people collect and process information (Felder & Brent, 2005; Felder, 1993).

The first dimension is related to the type of information that the student prefers to work with (perception: sensing - intuitive); the second analyzes in which modality sensory information is most effectively perceived (input: visual - verbal); the third relates to the actions that the student generates from the information received (processing: active - reflective) and the fourth indicates how the student builds his thinking from the organization and structuring of information (understanding: sequential - global).

In tables 1 to 4, the preferences of the students in the selected course are shown.

Table 1. Students with preference active-reflective.

| Preference | Number of students |
|---|---|
| Balance | 19 |
| Moderate active | 4 |
| Moderate reflective | 1 |
| Strongly active | 2 |
| Strongly reflective | -- |

Table 2. Students with preference visual-verbal.

| Preference | Number of students |
|---|---|
| Balance | 8 |
| Moderate visual | 13 |
| Moderate verbal | -- |
| Strongly visual | 4 |
| Strongly verbal | 1 |

Table 3. Students with preference sensing-intuitive.

| Preference | Number of students |
|---|---|
| Balance | 16 |
| Moderate sensing | 9 |
| Moderate intuitive | -- |
| Strongly sensing | 1 |
| Strongly intuitive | -- |

Table 4. Students with preference sequential-global.

| Preference | Number of students |
|---|---|
| Balance | 14 |
| Moderate sequential | 6 |
| Moderate global | 5 |
| Strongly sequential | 1 |
| Strongly global | -- |

### *3.2. Used material*

Some videos about the issue selected for the experience were found in the Web, but none of them satisfied our requirements. The main obstacle is the language: we need videos in Spanish, but most of them are recorded in English, and we didn´t find videos that suit the way we tackle the issue, so we decided to use tailor made videos, in other words, to make our own videos.

Different kinds of video-tutorials can be found on the Web. Some are just real classes recorded, where the whole class can be seen, like the one showed in Fig. 1 (a), others are focused on the board and the professor, like the one showed in Fig. 1 (b). A good example are the classes recorded from the professor Gilbert Strang, available at the Opencourseware of the MIT (http://ocw.mit.edu/resources/res-18-005-highlights-of-calculus-spring-2010/).

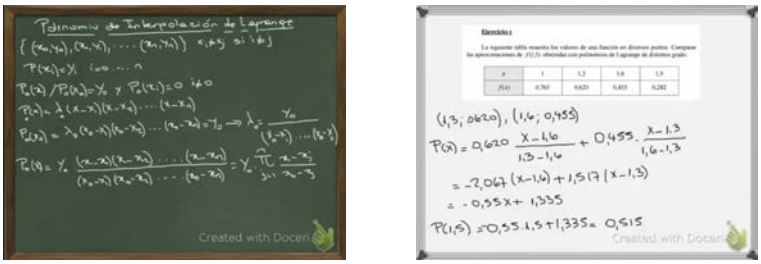

(a) (b)

Fig. 1. Real classes recorded.

Another way to record classes, is to use a software that converts a tablet into an interactive whiteboard -or blackboard!- and screencast recorder with sophisticated tools for hand-drawn graphics. While this software records what´s happening on the screen, it also records sound, so it is possible to record explanations while writing. Examples of this kind of software are Doceri by SP Controls Inc (doceri.com), ShowMe (www.showme.com), Educreations (www.educreations.com), Vittle by Qrayon (www.qrayon.com/home/vittle/), Knowmia and Chomp by Techsmith (www.techsmith.com). All of them have free versions for IPad, some have commercial versions for Windows.

In this case, Doceri was the software chosen. In this software, many different pen styles plus graphic lines and shapes are available, where size, color, opacity and spacing may be personalized. Using a finger or a stylus, a single page drawing, a multi-page presentation or an animated sequence may be created.

The issues tackled with video-tutorials were interpolating polynomial and spline functions. For each one, two kind of videos were prepared: one with the theoretical basis and the development of the method being studied, and the other describing the solution of an exercise, showing the implementation of the method. The maximum length of the videos is 15 minutes. Fig. 2 shows the different styles adopted, for theory and practice.




(a) (b)

Fig. 2. Tailor made classes for the experience, made with Doceri.

Once the videos were finished, they were uploaded on YouTube. They were not shared as public, but the links provided when doing the upload were shared with the students.

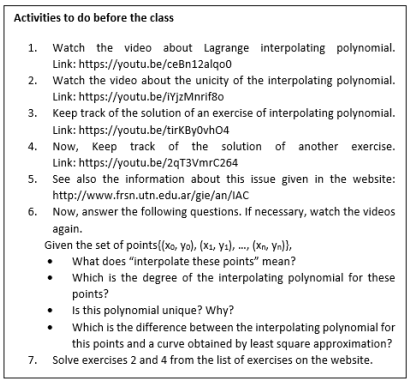
Students were also required to refer to the material of the website Interpolating and Adjustment of Curves (www.frsn.utn.edu.ar/gie/an/iac), designed by our group GIE where theory, solved exercises and some tailor made apps to interact with can be found.

### *3.3. Assignment of tasks*

We have worked with the virtual platform Piz@rrón (Caligaris et al, 2006) since 2006. The use of this tool is not entirely exploited. For example, students are not accustomed to using the communication tools like chat and forum. They prefer the e-mail. This probably occurs because our course is face-to-face, not a distance one. For this reason,

the platform is mainly used as a repository of files, notes and sets of exercises for each unit. Qualifications are also uploaded here, but it is not possible to hang up links to videos in this platform.

So as to give students the assignment of tasks, a teaching sequence was designed to guide them in the study of the issues selected for the experience. This sequence was uploaded on the platform in a pdf file, where the videos were linked, as shown in Fig. 3. Besides, some key questions were given to be answered by the students, so as they could focus on the important properties and definitions.



**Activities to do before the class**

1. Watch the video about Lagrange interpolating polynomial. Link: https://youtu.be/ceBn12alqo0
2. Watch the video about the unicity of the interpolating polynomial. Link: https://youtu.be/iYjzMnrif8o
3. Keep track of the solution of an exercise of interpolating polynomial. Link: https://youtu.be/tirKBy0vhO4
4. Now, Keep track of the solution of another exercise. Link: https://youtu.be/2qT3VmrC264
5. See also the information about this issue given in the website: http://www.frsn.utn.edu.ar/gie/an/IAC
6. Now, answer the following questions. If necessary, watch the videos again.

   Given the set of points$\{(x_0, y_0), (x_1, y_1), \ldots, (x_n, y_n)\}$,
   - What does "interpolate these points" mean?
   - Which is the degree of the interpolating polynomial for these points?
   - Is this polynomial unique? Why?
   - Which is the difference between the interpolating polynomial for this points and a curve obtained by least square approximation?
7. Solve exercises 2 and 4 from the list of exercises on the website.

Fig. 3. The didactic sequence given to the students

As Moodle is being implemented in our institution, our next practices of flipped classroom will be done in this learning environment, because it has more and different tools, suitable for the activities needed when the flipped methodology is implemented.

### *3.4. Development of the class*

At the beginning of the class, it was inquired how many students had seen the videos. This fact was crucial to continue. Fortunately, almost all students raised their hands. So, only a brief summary of the definitions and properties of interpolating polynomial and spline functions was done, and the answers to the given questions were reviewed. Then a discussion arose about the exercises assigned to do at home, and the solutions were outlined on the board, with the students' participation.

After that, some other exercises were proposed to be solved by the students. Some of them tried to get the solution with enthusiasm, while others just waited for the exercise to be discussed on the board. The relation student:teacher was 10:1, so every question was answered almost immediately.

### *3.5. Survey*

The experience was carried out so as to ask students' opinion on the methodology of flipped classroom, in order to implement it in an entire course during next year. Data was gathered by means of an anonymous survey requested to all students that participated in the experience.

The survey covered three aspects of the experience: the use of time outside the class to accomplish the duties, the opinion and usefulness of the given material, and the opinion of the used method, compared to the traditional class. In particular, they were asked how many times they had seen the videos, their opinion about them, if they had consulted the website and if they needed some extra material to completely understand the issues studied. A key question was also made about which method they preferred for learning: the traditional or the flipped one.

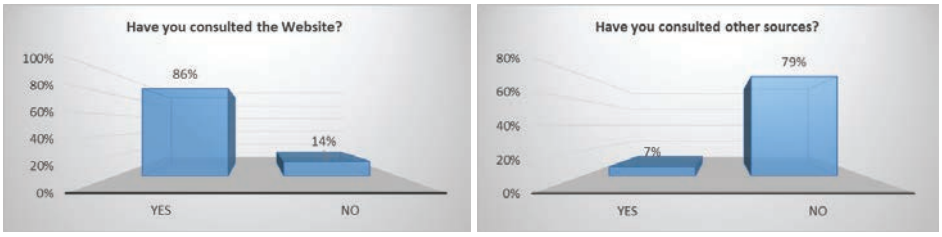
## 4. Findings

The experience showed a high degree of students' acceptance with respect to the methodology of the flipped class. Students were satisfied with the videos presented, and in general they preferred to work in class on their own, with the assistance of the faculty, rather than having the assistant solving exercises on the whiteboard.

Ninety-six percent of students watched the videos. Only one student said that he did not see them, because he had no time. Most students saw the videos once, but some of them watched them three or four times. Eighty-six percent of students answered "yes" to the question "Have you understood the issue from the given videos?" Then, it can be concluded that the videos helped students to understand the issue being studied. Some of the reasons they exposed were:

- *"Concepts are better fixed to me, besides it is comfortable to be at home…"*
- *"Because the explanations were not different from the ones given in class, and I had time to take notes and keep track on details"*
- *"I could see the method step by step and pausing. In class I cannot copy everything and I lose explanations"*
- *"Note-taking was easy"*
- *"Because they were clear and short. But going to class helped me to understand the issue more clearly"*
- *"Because I could pause the explanation whenever I wanted and go backwards as often as necessary to understand what was being done"*
- *"Because they are clearly explained and supplemented with exercises"*
- *"Because I rewound as many times as I wanted and took the necessary notes"*

As stated before, websites of the issues developed in the classes have been used from some years. We wanted to know if students still consulted the websites, despite the fact that they had the videos. When we asked if they had consulted the website, most of the students answered "yes", as it can be seen in Fig. 4 (a).




(a) (b)

Fig. 4. Consults to the website and other sources

Thirty-five percent of the students consulted the website before watching the videos. Some explanations were:

- *"So as to anticipate the issues being studied"*
- *"To check whether I understood"*
- *"To fix concepts"*
- *"Because I always visit the sites"*
- *"To supplement"*
- *"Because I have to read the content before I start studying the issue (I saw the videos later)"*

Fifty-three percent of students consulted the website after watching the videos. Some explanations were:

- *"To try to deepen the topic, and examine some other solved exercises"*
- *"To study"*
- *"For the evaluations"*

But when we asked about going to other sources of information about the issue being studied, almost eighty percent of students said “no”, as shown in Fig. 4 (b). Some of the reasons were:

- *“With the class material and the notes I´ve taken, it is sufficient”*
- *“Only my notes, because information was understandable”*
- *“In the videos and in my notes I found the information given in class”*
- *“Because I have found enough information, and because some sources are difficult to understand without a professor´s guidance”*
- *“Because the website was enough for me”*

Another important question was if they found it more useful to do the exercises by themselves in class instead of having them solved on the board. Seventy-two percent of students answered “yes” to this question. Some of the reasons they exposed were:

- *“It helped me solve the exercises”*
- *“Because I could find my own mistakes when solving them”*
- *“Because I can ask questions when I have doubts”*
- *“Because I can ask about the procedure when solving them”*
- *“Because it helps to do more exercises alone”*
- *“It helps to become aware which part I don´t fully understand”*

Finally, students were asked which methodology they prefer. Results are shown in Fig. 5.

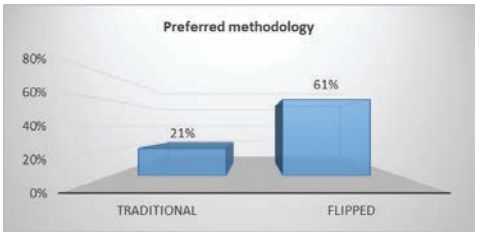



Fig. 5. Student´s preference about the methodology

## 5. Conclusion

From the students´ point of view, the survey showed a high degree of acceptance with respect to the methodology of the flipped class. In class the students showed their enthusiasm, and their interest was noted from the moment the experience started. Students were satisfied with the material offered, and in a high percentage, they preferred to work in class on their own, with guidance, rather than having the assistant solving exercises on the board. This was partly the expected result, as the flipped classroom methodology fits perfectly with the learning style historically identified in students. In general, the use of YouTube is widespread among them, so it was not an obstacle for them to access to the published material.

From the academics´ point of view, the videos developed for this experience, together with the material offered on the websites of the subject, gave the students the necessary tools to achieve autonomy in the study of theory, making it possible to change the way of working in class. But the experience turned out to be a major challenge. On the one hand, the development of our tailor made videos involved a great time spent on finding the right tool and learning how to use it. On the other hand, it was not easy to change the role when exercises have to be solved: we had to let students work alone –with our assistance–, and that takes more time than that spent when exercises are explained on the board.

This brief experience not only helped to obtain the opinion of students. From the teachers´ experience, we found that it was needed to devote much more time to preparing material for a flipped classroom –videos to watch as well as activities to carry out in class– at least for the first time. It was also found that the classes were much more dynamic.

This time, academic achievements were not measured. Only the response from students with respect to the change in methodology was analyzed. The next step is to organize a new experience, quite longer, evaluating the educational outcomes.

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